Correlation between Radial Variation and Mechanical Properties of Laminated Veneer Lumber made from 14 Poplar Cultivars

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Introduction

The veneer processing industry use almost exclusively one poplar cultivar (I-214) for light packaging products. In case of a disease, this could lead to a shortage of raw material or a significant loss in wood quality (Haouzali 2009). Consequently it is necessary to diversify the source of genetic material.

the demand for wood products for building has increased

Engineered Wood Products (EWP) have been developed and manufactured

France is the largest grower of poplar in Europe. It had 236,000 ha (FAO 2008). Total poplar harvesting in 2009 was 1,3 million m^3 (FCBA 2011)

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Introduction (2)

1) Less lumber defect (knots, cracks and other defects)
2) Stable in dimension and more resistant to warp, twist, bow, and cup;
3) Available in large dimensions

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However, the production of high quality LVL would be faced against two main problems:
1) veneer quality (mostly geometrical quality and in a second step aspect quality);
2) presence of important rate of juvenile wood, mature wood being often close to harvesting age.

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Objective

The objectives of this research were to analysed the effect of juvelinity and veneer thickness on mechanical properties in each 14 poplar cultivar

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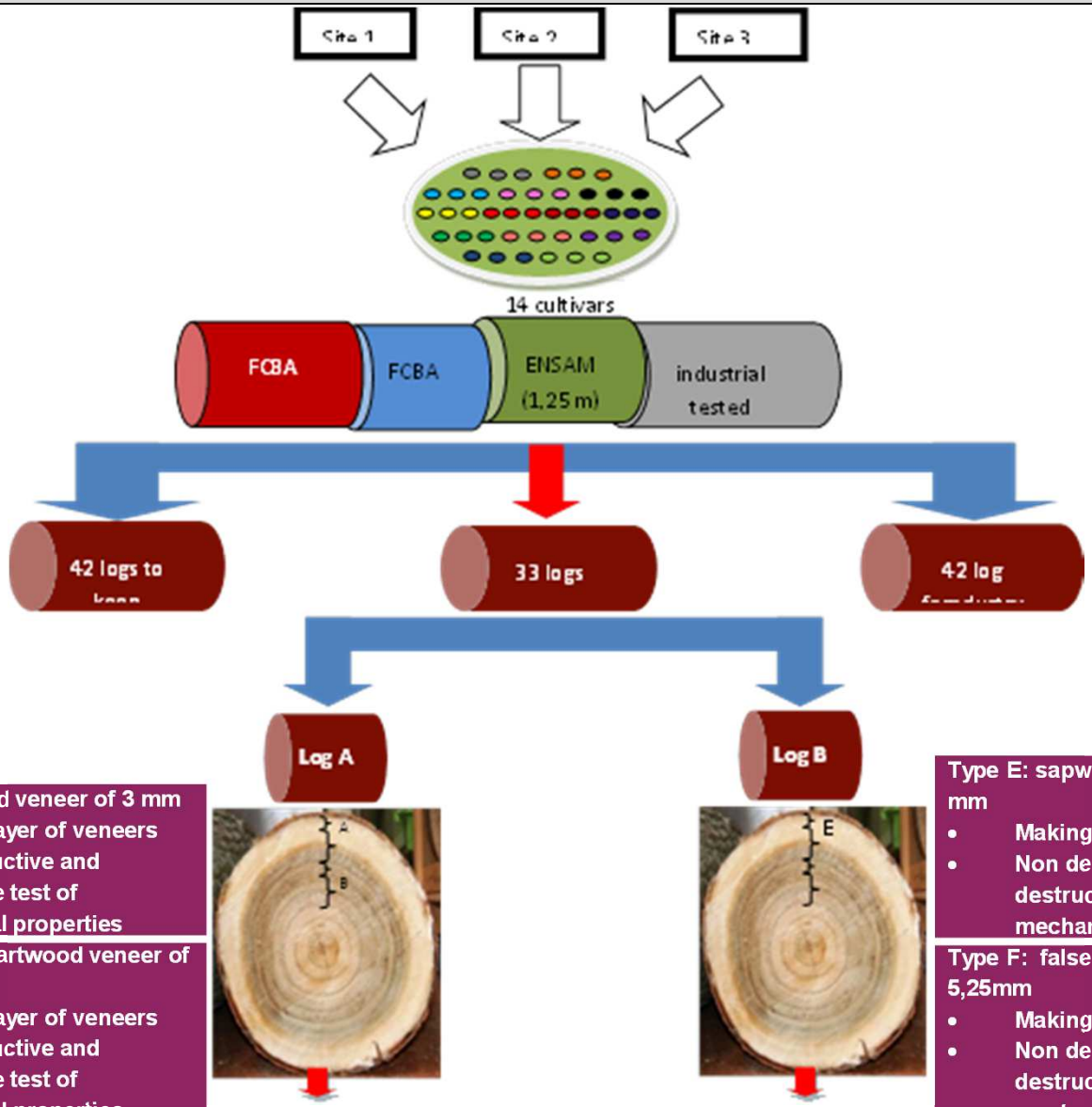
Sample Preparation



Type B : sapwood veneer of 3 mm
- Making 7 layer of veneers
- Non destructive and destructive test of mechanical properties

Type D: false heartwood veneer of 3mm
- Making 7 layer of veneers
- Non destructive and destructive test of mechanical properties

Type E: sapwood veneer of 5,25 mm
- Making 4 layer of veneers
- Non destructive and destructive test of mechanical properties

Type F: false heartwood veneer of 5,25mm
- Making 4 layer of veneers
- Non destructive and destructive test of mechanical properties

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LVL Production

Veneer Selection

Poplar cultivars : Brenta, Dvina, I-214, Koster, Lambro, Lena, Mella, Soligo, Taro, A4A, Alcinde, Polargo, Trichobel, Triplo

From each log, we manufactured two types of panels:
- A panel made of "adult" veneer (type B and E);
- A panel made of juvenile veneer (from false heartwood - type D and F).

We made LVL of 7 layer from 3 mm veneer and 4 layer from 5.25 mm veneer, so that the average thickness of our LVL was 21 mm.

All of veneers had already been dried until they reached 8 - 10% of moisture content.

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Gluing Process

- We used PVAc (Poly Vinyl Acetat) as adhesive. The vinyl adhesive that we used was marketed under the name "Rakoll®" _GXL 4. It is in the form of an emulsion and ready for application.
- We produced 188 LVL panels of 21 mm thickness and 500 mm x 500 mm surface

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Preparation Samples for Mechanical Properties

- Each board was cut into standardized test samples (EN 789), parallel to grain with 10 samples for each board specimens for testing non-destructive characterization and static bending.
- BING: 3720 (1860 x 2) samples
- static bending and MOR : 1860 samples
- The parameter that we used for mechanical properties were Modulus of Elasticity (MOE) and Modulus of Rupture (MOR) computed according to the procedure detailed into the norme EN310.

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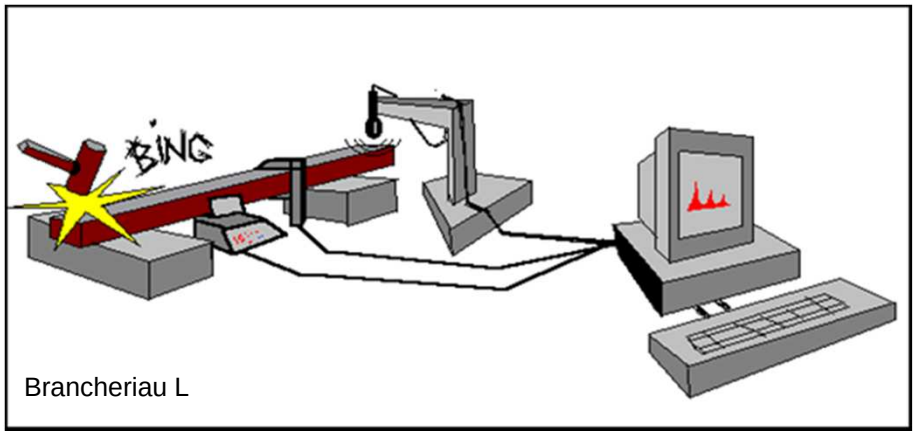
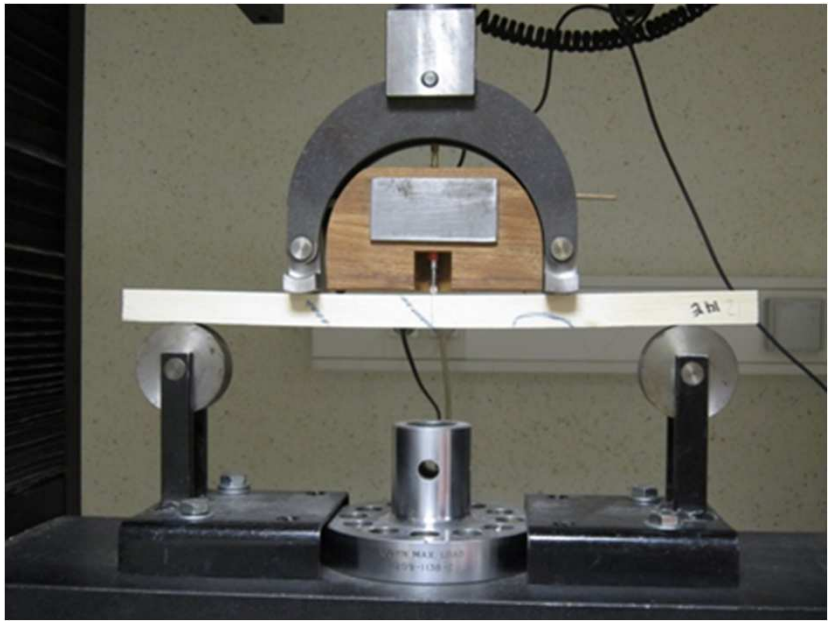
Non destructive (BING) and Destructive Test (Instron)



Brancheriau L



- 4 point bending
- Load range of 5000 N at a constant speed 5mm/min until the samples broke
- Obtained MOE and MOR

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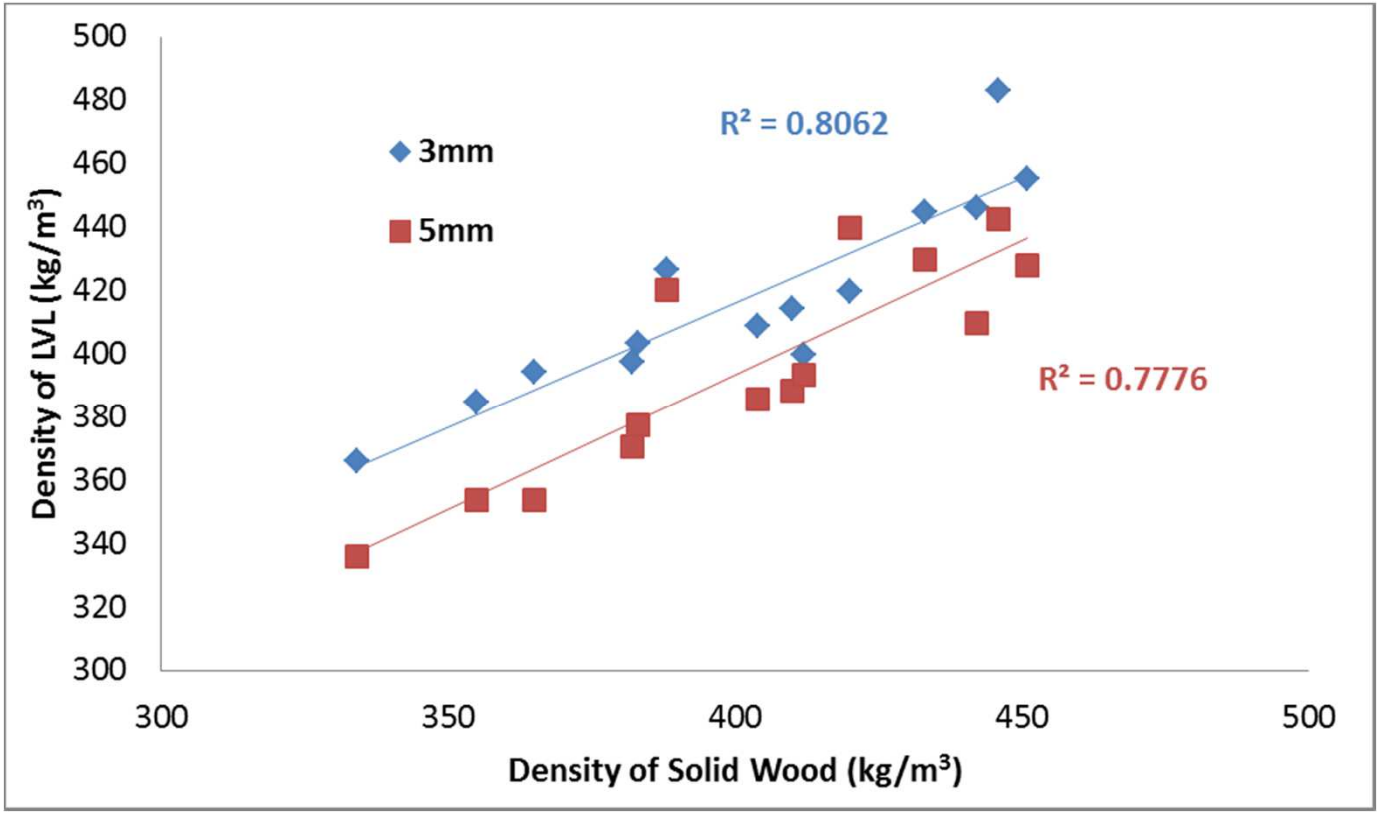
Density



- The equilibrium moisture content was very homogeneous (8.5 ± 0.5%).
- There was a very good correlation between the densities of LVL made from veneer 3 and 5 mm and densities of solid wood (R^2 = 0.81 and 0.78 for 3 and 5 mm subsequently) (Figure top)
- These results were very satisfactory from the point of view of the homogeneity of the samples that we used in this research.

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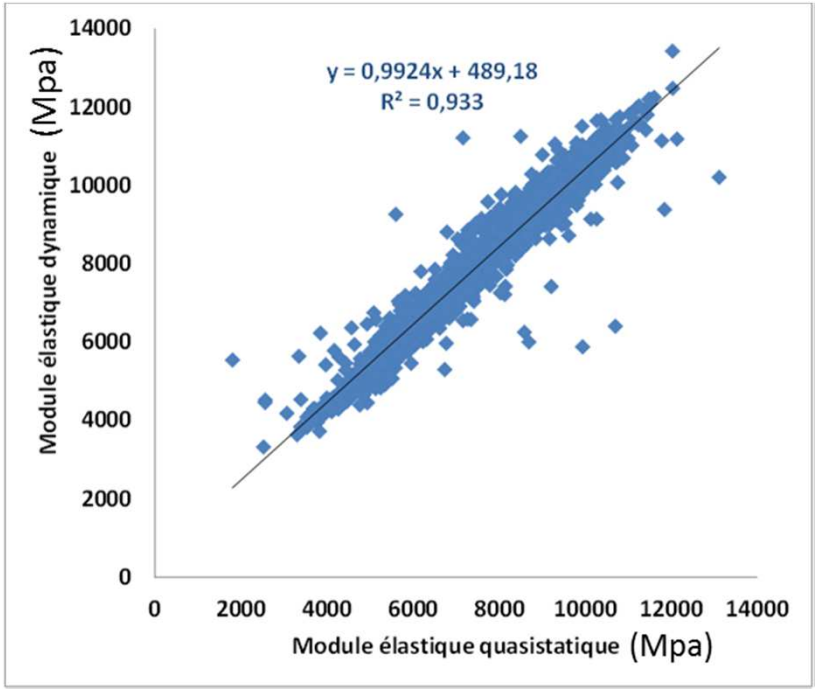
Modulus of Elasticity (1)



- (Figure top) showed the correlation between MOE Static and MOE Dynamic for all samples tested (LVL in flatwise and edgewise direction) (1903 samples, 3mm thick veneers). The correlation was excellent ($r^2 = 0.93$).
- This indicated that BING was a reliable non destructive instrument for mechanical grading Poplar based on MOE.
- It was correspondence with Haouzali (2009), noticed the same relationship between dynamic and static module of Poplar LVL (correlation coefficient (r) of the regression is 0.88 and the determination coefficient (r2) is 0.77, with highly statically significant at the 1% level). It was also shown that the dynamic MOE is always slightly higher than the static MOE.
- The resonance method is interesting to predict stiffness which is often penalizing poplar form mechanical classment. Industrial control plywood and LVL boards could be possible with BING method (Haouzali 2009).

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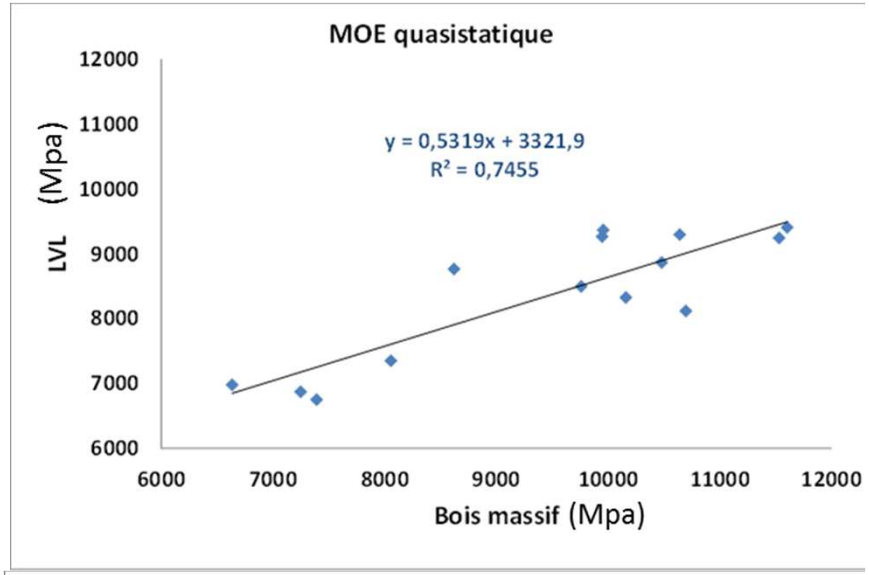
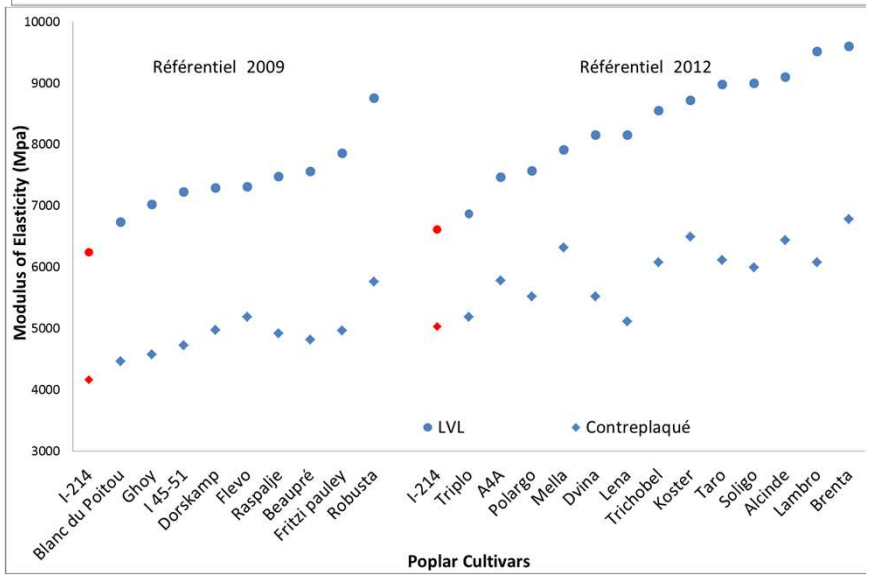
MOE (2)

- The MOE values that we used were the average values from LVL made from 3 mm and 5 mm veneers in flatwise and edgewise bending test. The results were very well correlated with MOE of solid wood (Figure Top), in line with Haouzali (2009)
- However, as Haouzali (2009) observe it, the MOE of LVL were generally lower than the MOE of solid wood.
- Thus, for the LVL, there were cultivars with high rigidity values (Lambro, Brenta, Taro, Alcinde, Soligo, Lena, Koster) and three cultivars (I214, A4A and Triplo) were unsuitable for structural applications (Figure Down).





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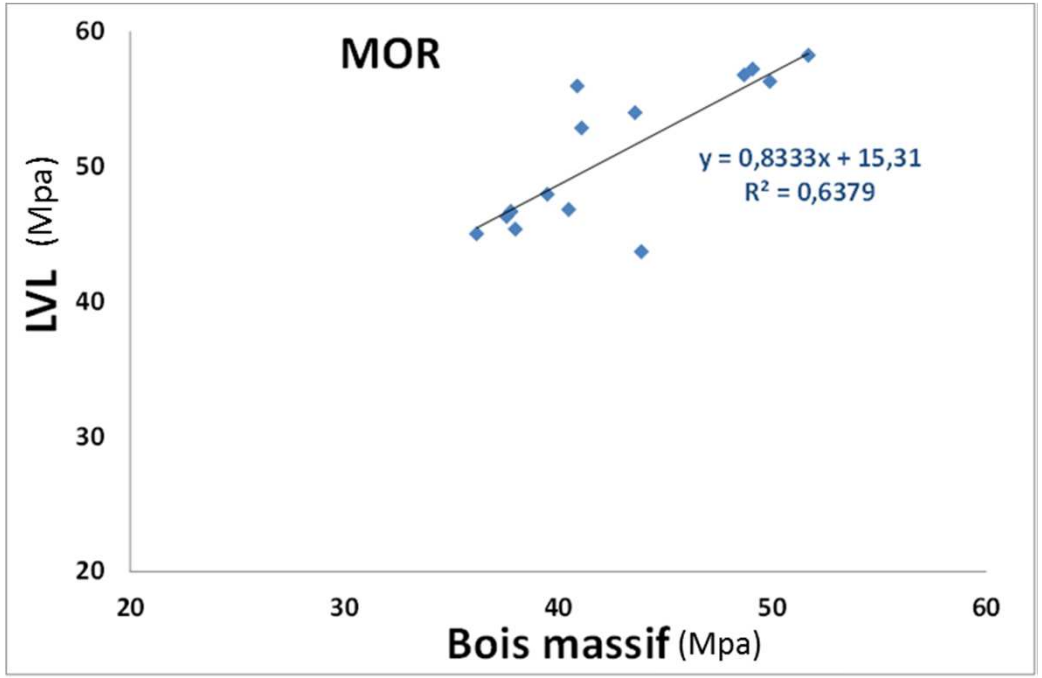
Modulus of Rupture (MOR)



- The comparison of the MOR values between LVL and solid wood also showed a good correlation. The effect of lamination combined with adhesive performed significantly improved the MOR of these cultivars (about 20% on average compared to solid wood)
- The poplar LVL and plywood proprieties can be influenced considerably by the cultivar, the glue type and the veneer thickness (Haouzali 2009).

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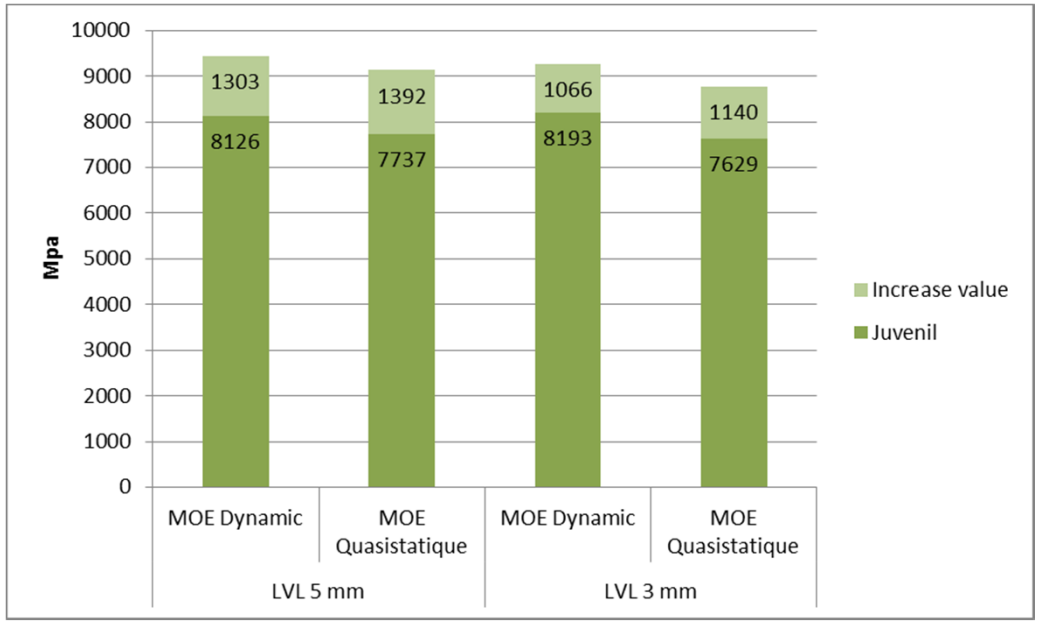
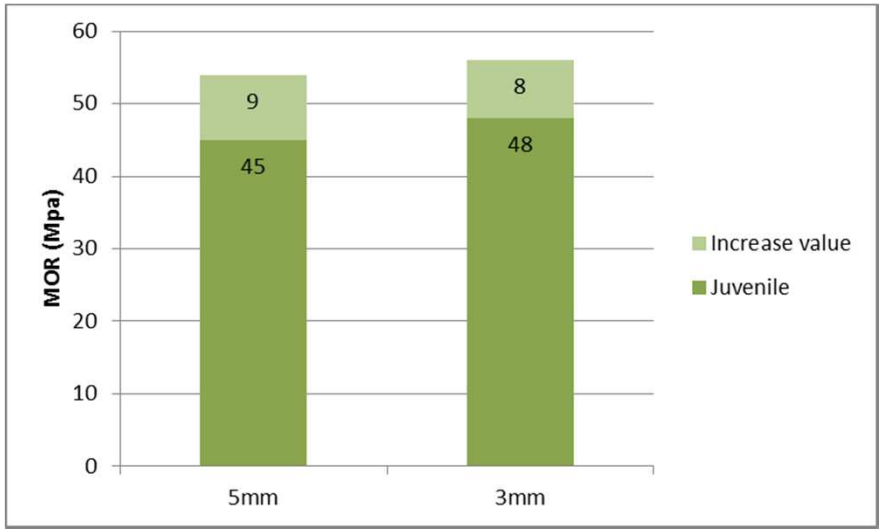
Effect of Radial Position





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Effect of Radial Position

- The advantage of using veneers taken from sapwood , and therefore supposed to be less juvenil than heartwood, is obvious since the mechanical properties are much better (between 14 to 21%) for a comprarble density (Table down). This proved that there was an effect due to juvelinity in every poplar cultivar. It also showed that LVL from 5 mm veneers had the highest increase percentage from juvenile to mature in MOE dynamic, MOE quasistatique MOR and density, 16%, 18%, 21% and 2% subsequently.

Mean Value of 14 Poplar Cultivars		MOE dynamique (MPa)	MOE quasistatique (MPa)	MOR (Mpa)	Density (kg/m^3)
LVL 5 mm	Mature	9429	9129	54	400
	Juvenile	8126	7737	45	390
gain in %		+16	+18	+21	+2
LVL 3 mm	Mature	9259	8769	56	417
	Juvenile	8193	7629	48	412
gain in %		+13	+15	+16	+1

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Conclusion

- BING, was reliable instrument for estimating MOE from destructive test. Some cultivars have a real potential for structural applications (Lambro, Soligo, Alcinde, Brenta and Taro) while others could be excluded (A4A, I-214, Triplo).

- All cultivars could be well peeled and presents an excellent peelability as [NURBAITY.2012]. General cutting conditions used for I214 were applied for the 14th cultivars.

- There was significant variation sapwood to heartwood (supposed mature to juvenile wood) for each cultivar. The difference of mean MOE and mean MOR between juvenile and mature LVL were 15% and 17% for an increase of density of 1%. Finally, the use of thicker veneers reduced the use of adhesive, simplified and accelerated the production of panels without altering their mechanical properties.

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Thank You – Merci Beaucoup – Terima Kasih

Any Questions ?

Doctorants LaBoMaP

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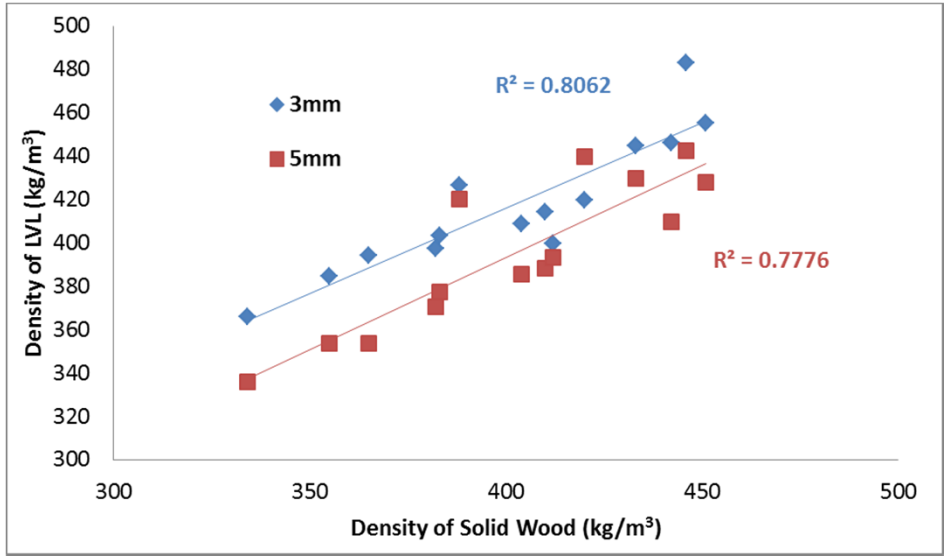
Density



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- There was a very good correlation between the densities of LVL made from veneer 3 and 5 mm and densities of solid wood (R^2 = 0.81 and 0.78 for 3 and 5 mm subsequently) (Figure top)
- These results were very satisfactory from the point of view of the homogeneity of the samples that we used in this research.
- The observed discrepancy between the densities of LVL 3 and 5mm was systematic (intercept of linear regressions difference about 50 kg/m^3) and mainly due to the removal of three glue line between the two lay up. They were about 30 kg/m^3 because the weight adhesive application was about 200 g/m^2.